Presented for the FHWA

Corrosion Resistant Reinforcing Bar Seminar

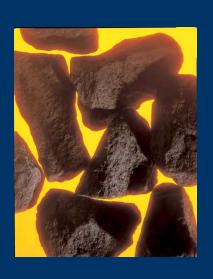
Florida DOT – July 17, 2012

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### What is Basalt?

- ◆ Volcanic Rock worldwide deposits
- Specific Gravity, Density & Weight same as Granite
- ◆ Natural Material No Additives
- ◆ Quarry, Crush & Re-Melt (2700°F)
- ◆ Spin Process = Rockwool
- Drawing Process = Continuous Basalt Fiber (CBF)

# Rockwool – Spin Process









# CBF – Drawing Process





## Continuous Basalt Fiber - CBF

- ◆ Drawn through Platinum-Rhodium die with 200-800+ orifices
- ◆ Each Fiber is 10-20 microns diameter Hair = 40-120 Copy Paper = 100
- ◆ Coated with "sizing" for end use
- Grouped in strands called "tow"
- Wound on bobbin called "Roving"

## **Basalt Fiber Products**

- ◆ Textiles Fireproof Material
- ◆ Automotive Brakes & Mufflers
- ◆ Aerospace Alternate to Carbon
- Construction
  - -Chopped fiber enhances performance
  - Grid alternate to WWF
  - Bars alternate to steel
  - Fabric for Epoxy Wraps

## **Chopped Basalt Fiber**

- ♦ ½" to 2" lengths
- 3 to 5 lbs / cu.yd. dosage
- Early age reduces cracking
- ◆ Final stage
  - Compressive up 10%
  - Tensile Increase
  - Can eliminate WWF



## **Basalt Grid**



- Woven Strands
- Coating
  - Epoxy
  - Asphalt
- ◆ Alternate to WWF

- ◆ Same pultrusion process as Glass
- ◆ New Wet Lay-up Process
- ◆ Same types of resins as Glass
- Various kinds of deformations
- ◆ Higher Strength
- ◆ Higher Modulus
- ♦ Higher Strain



## BFRP Rebar Properties

- ◆ Tensile = 116~174 ksi (800~1200 MPa)
  - Glass =  $70 \sim 120$  ksi ( $480 \sim 825$  MPa)
  - Steel = 70~100 ksi (480~690 MPa)
- $\bullet$  Modulus =  $6.5 \sim 10.1 \times 10^3$  ksi (45-70 GPa)
  - Glass =  $5.1 \sim 7.4 \times 10^3$  ksi  $(35 \sim 51 \text{ GPa})^3$
  - Steel = 29 x 10<sup>3</sup> ksi (200 GPa)
- ♦ Strain = 2.37 ~ 3.09% (ultimate)
  - Steel = 0.14 ~ 0.25% (yield)

## BFRP Rebar Sizes (sample)

	<u>Size</u>	<u>Tensile (ksi)</u>	<u>Bar (kip)</u>	Modulus (x10³ ksi)
•	2.5mm	162.4	1.2	5,884
•	3mm	161.7	1.8	5,890
•	4mm	161.0	3.1	5,901
•	5mm	160.3	4.9	5,912
•	6mm (#2)	159.5	7.0	5,923
•	8mm	158.1	12.3	5,946
•	10mm (#3)	156.6	19.1	5,969
•	12mm (#4)	155.2	27.2	5,991
•	16mm (#5)	152.3	47.5	6,037
•	18mm	150.8	59.5	6,060
•	20mm (#6)	149.4	72.7	6,083
•	22mm (#7)	147.9	87.2	6,106
<b>*</b>	25mm (#8)	145.8	110.9	6,141



- Route A509County FermanaghNorthern Ireland, UK
- Single Span = 105 feet (32m)
- Width = 26 feet (8m)
- ♦ Skew = 63°
- Integral Abutments
- Precast Prestressed U-Beams
- Precast Stay-in-Place Forms



### **Deck Spans**

4.59' between beams

5.25' over U-beams

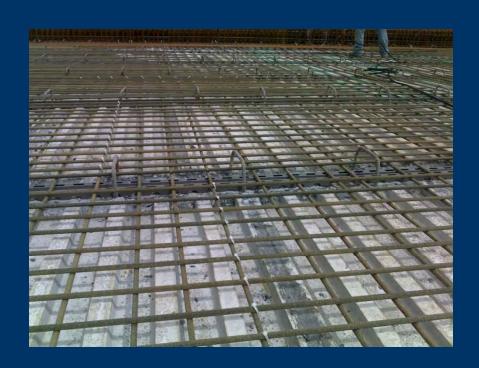
### Reinforcing

0.6% BFRP Bars

0.7% Steel Bars

### Loading

40 ton on 11.8" dia. Plate (15 Max Euro Wheel Load)



#### Test Results - Deflection

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Span = 4.59' (1.4m)
0.012~0.019 in.
(0.30~0.48mm)
L/2917
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Span = 5.25' (1.6m) 0.013~0.045 in. (0.33~1.14mm) L/1404



Steel = Up to Twice as much!

#### Test Results - Strain

Measured Ultimate BFRP Bar 0.671 (17037 με)

Maximum Recorded Test 0.078 (1993 με)

Max = 11.7% of Ultimate

Safety Factor = 8.5

Good recovery after test back to service load values



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Questions?